Efficient price discrimination in the wholesale electricity market

Response to the Electricity Authority Market Monitoring Review

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In its discussion paper, *Inefficient Price Discrimination in the wholesale electricity market – issues and options,* the Electricity Authority (Authority) wrongly characterises the Tiwai contracts as an example of inefficient price discrimination. Rather than an efficiency *loss* of $57 million to $117 million as arrived at by the Authority, the better measure of the total efficiency *gains* from the Tiwai contracts (relative to a scenario in which the smelter ceased production) is around $40 million to $120 million per annum, applying the Authority's assumptions consistently.

Little weight, however, should be given to the specific results from applying the Authority's assumptions, as many of those assumptions are questionable and abstract from elements of the contracts that produce value for New Zealand but which are not considered in the Authority's analysis (for example, locational prices, demand response, transmission costs).

This report discusses two sources of error in the approach taken by the Authority.

Firstly, the Authority did not arrive at a clear problem definition—its descriptions of the problem differ from its reviewers and the reviewers differ among themselves. In its discussion paper and supporting peer reviews, the Authority published three different views as to what constitutes inefficient price discrimination:

- prices that differ between customers for reasons other than quantifiable differences in costs (Authority)
- charging some consumers lower prices when other customers, who place a higher value on electricity, consume less or not at all because they face higher prices and/or the cost of producing electricity is higher than the value of its use (Mr Duignan)
- the sale of electricity at prices below the economic cost of supply (Mr Hunt).

Without a clear problem definition, there was no solid foundation for the Authority's analysis.

Second, the analysis undertaken by the Authority was not grounded in the extensive literature on the issue it was investigating—price discrimination. Economic research provides elegant and powerful results showing that discriminatory prices can enhance output and increase economic welfare.

The key test from the literature is whether price discrimination increases output (either by serving more customers or increasing the amount they consume), rather than merely shuffling prices paid by pre-existing customer groups without an increase in output. The tests applied by the Authority, for distinguishing efficient and inefficient price discrimination, are at odds with this established literature.

As the Tiwai contracts unambiguously lead to a large increase in electricity output relative to the Authority's counterfactual scenario of the smelter exiting New Zealand, one of two possibilities arise:

- the received economics literature is wrong, and the Authority has shown that price discrimination can expand output and be welfare reducing
- the Authority is mistaken.

We show the Authority wrongly interprets its own analysis and Appendix B of its discussion paper provides an example of welfare enhancing price discrimination, not inefficient price discrimination as the Authority concludes.

Even under the Authority's own calculations, the increase in aluminium prices since the contracts were finalised, means the Authority would determine that the contracts result in an increase in economic welfare were it to repeat the calculation with current knowledge. The Authority, in effect, is proposing regulatory options in its Discussion Paper that would have precluded a contract that it now knows to be welfare enhancing on the grounds that it (the Authority) would not have foreseen that benefit when it applied its proposed regulatory tests.

There is no economic foundation to the Authority's claims that generators have subsidised the price of electricity to the smelter. The Authority's claim was based on an analysis that compared the price paid under a commercially agreed contract by a low-cost supplier (hydro generation), with the cost of the highest cost existing supplier (approximated by thermal generation). The Authority's definition of a subsidy would imply that an efficient new entrant should not enter into a contract at prices below that charged by the incumbents; a test that would make it very difficult for the Authority to pursue its objective of promoting competition for the long-term benefit of consumers.

The Tiwai contracts do result in a significant net gain to producer surplus under the Authority's characterisation of the contracts and its assumptions. In of itself, this observation is nothing more than the 'invisible hand of the market' at work; generators were incentivised to negotiate a contract that resulted in a net benefit to New Zealand.

1. Introduction

The Electricity Authority (Authority) makes a number of strong claims in its discussion paper, *Inefficient Price Discrimination in the wholesale electricity market – issues and options* (Discussion Paper) (Electricity Authority, 2021). The Authority claims price discrimination implicit in the 'Tiwai contracts' between Meridian Energy, Contact Energy, and the New Zealand Aluminium Smelters (NZAS) provide a potential illustration of price discrimination not in the longer-term interests of consumers and result in (Electricity Authority, 2021, p. ii):

- potential inefficiency costs of around $57 million to $117 million per year
- subsidies from electricity generators to NZAS of $500 million over the contract's four-year term
- generators being willing to subsidise NZAS because the Tiwai contracts result in other consumers paying an additional $850 million per annum
- market prices that distort signals for investment in generation and electrification, thereby compromising the efficient transition to a low emissions economy.

We test the validity of the Authority's claims. Our report is structured into four sections:

- Section 1 introduces our report and outlines its scope.
- Section 2 summarises the Authority's view of what constitutes efficient and inefficient price discrimination and assesses whether the Authority's view accords with the findings of relevant economic literature.
- Section 3 reviews whether the Tiwai contracts, when assessed against the tests in the economic literature of efficient and inefficient price discrimination, give rise to economic efficiency losses or efficiency gains.
- Section 5 concludes.

2. Economics of price discrimination

2.1 The Authority's view

The Authority explains that its focus is primarily on the allocative inefficiencies that can arise from price discrimination (Electricity Authority, 2021, para 5.2). It notes, almost in passing, that price discrimination can enhance economic efficiency (Electricity Authority, 2021, p. ii). However, there is no clear statement from the Authority as to what it considers distinguishes efficient price discrimination from inefficient price discrimination.

One interpretation of the Authority's view can be gleaned from an option it contends would counter inefficient price discrimination. In describing its option 7 (non-discriminatory pricing rules), the Authority explains it could write a rule that prevents "generators or other electricity market participants from offering electricity hedges at lower (or higher) prices to different customers absent a credible and quantifiable justification." (Electricity Authority, 2021, para 6.47). The Authority elaborates that sellers (Electricity Authority, 2021, 6.52):

> would not have to offer the same electricity price to all parties, but rather would be required to attribute price differences directly to differences in the costs of services … These differences might include aspects such as timing of offer, node, volume economies, duration of contract, credit rating of counterparty, consumption profiles, demand response provisions and other terms and conditions.

The implication is that the Authority views efficient price discrimination occurring only when the difference in price reflects a "quantifiable" difference in the cost of supply.[1] However, the Authority suggests it would permit prices to vary for reasons other than cost when the sale is for an activity the Authority views favourably; the Authority gives the example of a discount to a retailer supplying vulnerable customers (Electricity Authority, 2021, para 6.52). The Authority does not explain how it will select those customers who would be permitted to benefit from price discrimination for reasons other than economic efficiency.[2]

In his peer review, Mr Duignan comments on the Authority's summary of its problem definition which states (Electricity Authority, 2021, pg 22):

> With inefficient price discrimination, the right consumers are no longer consuming the right amounts of electricity – the allocation of electricity to different consumers may be inefficient or the cost of producing electricity may be higher than people value it at.

As Mr Duignan observes, the Authority's statement does not define the right consumers or the right amount (nor, we would add, does it define what it means by the cost of producing electricity).

[1] The Authority seems to overlook that price discrimination could be present even when all consumers are charged the same price; this is a surprising omission given its efforts in recent years to explain that uniform transmission pricing inefficiently discriminates amongst transmission customers.

[2] This selection criterion would be important as the Authority says that, under its rules based approach, penalties should at a minimum exceed the private benefits the deal bestows on the parties to the contract and ideally should approximate the social harm done (Electricity Authority, 2021, para 6.56).

However, Mr Duignan suggests other sections of the Authority's paper do provide a more precise explanation which he summarises as (Duignan, 2021, pg 2):

> inefficient price discrimination results in some consumers being favoured with lower prices who have a lower valued use for the electricity than other consumers or potential consumers who consume less or not at all because they face higher prices and/or the cost of producing electricity may be higher than the value of its use.

Mr Duignan does not reference the sections of the Authority's paper he is referring to in arriving at his summary of the Authority's views. However, as the Authority published its Discussion Document after receiving Mr Duignan's review and did not amend its summary, it seems reasonable to assume that the Authority agrees that Mr Duignan's expansion encapsulates one of its views (along with its incompatible view that inefficient price discrimination occurs when prices vary for reasons other than differences in quantifiable costs to serve).

The Authority's second peer reviewer, Mr Hunt, also comments on the Authority's discussion of its problem definition and summarises the Authority's views as (Hunt, 2021, pg 22):

> The issues paper focuses on the potential for economic efficiency losses to arise from price discrimination, particularly allocative inefficiency effects including from the sale of electricity at prices below the economic cost of supply.

Hence, the Authority, in its discussion paper and supporting peer reviews, has published three different views as to what constitutes inefficient price discrimination:

- prices that differ between customers for reasons other than quantifiable differences in costs (Authority)
- charging some consumers lower prices when other customers, who place a higher value on electricity, consume less or not at all because they face higher prices and/or the cost of producing electricity is higher than the value of its use (Mr Duignan)
- the sale of electricity at prices below the economic cost of supply (Mr Hunt).

Neither the Authority nor its reviewers cite any economic literature in support of their contentions. Though the Authority and Mr Hunt both state that price discrimination may be efficient, neither explain the circumstances in which price discrimination is efficient.

2.2 Price discrimination in economics literature

Price discrimination has long been studied in economics. We provide below an overview of the key conclusions from the literature. In Appendix A, we present a simple theoretical model to illustrate when a price discrimination strategy may give rise to economic inefficiencies and when it gives rise to economic efficiency gains.

In her seminal book "The Economics of Imperfect Competition", originally published in 1933, (Robinson, 1969), argues that some degree of discrimination will almost certainly be desirable. Following (Pigou, 1920), economists generally distinguish between three types of price-discrimination (Varian, 1989):

- First-degree (or perfect) price discrimination— involves the seller charging a different price for each unit of the good in such a way that the price charged for each unit is equal to the maximum willingness to pay for that unit.
- Second-degree price discrimination (or nonlinear pricing)—occurs when prices differ depending on the number of units of the good bought, but not across consumers. That is, each consumer faces the same price schedule, but the schedule involves different prices for different amounts of the good purchased. Quantity discounts or premia are the obvious examples.
- Third-degree price discrimination—occurs when consumers are charged different prices but each consumer faces a constant price for all units of output purchased. This is probably the most common form of price discrimination. The textbook case is where there are two separate markets, where the firm can easily enforce the division. An example would be discrimination by age, such as youth discounts at the movies.

(Robinson, 1969) observes that under conditions of perfect competition, price discrimination cannot exist.[3] However, if there is some degree of market imperfection, some degree of price discrimination becomes feasible. When markets are imperfect (as all real-world markets are), and customers do not have perfect information and cannot always move without cost from one seller to another, price discrimination becomes practicable.

Writing nearly 90 years ago, (Robinson, 1969) argued that price discrimination depends on customers having different elasticities of the demand. If all customers changed their demand by the same amount in response to a price change, then suppliers would charge the same price to all their customers as they would gain nothing from price discrimination. If customers differ in their elasticity of demand, suppliers have an incentive to charge higher prices to the least elastic (least price sensitive) customers, and lower prices to the most elastic (most price sensitive) customers.

Writing more recently, initially for a chapter in the Handbook of Industrial Organisation and then a standalone article, (Varian, 1996) concludes that if price differentiation allows more consumers to be served or increases output, it will generally increase welfare. However, price differentiation that merely shuffles prices paid by pre-existing customer groups and that does not result in an increase in the number of customers served, or the amount that they consume, will tend to reduce overall welfare (Varian, 1996). Therefore, (Varian, 1996) concludes that:

> the key concern in examining the welfare consequences of differential pricing is whether or not such pricing increases or decreases total output.

(Baumol, 2005) demonstrates why, under competitive conditions, a firm will normally be forced to adopt discriminatory pricing wherever that is feasible. He argues that uniform pricing is not to be taken as the normal characteristic of equilibrium of the competitive firm. Rather, Baumol maintains that discriminatory pricing is the normal attribute of equilibrium wherever customers have different

[3] Textbook models of perfect competition include assumptions of perfect information, homogeneous products, an infinite number of buyers and sellers, the absence of economies of scale, independence of action, and free movement of resources.

willingness to pay, and it is possible for the firm to prevent consumers in separable groups from reselling products to one another.

(Baumol, 2005) argues that discriminatory pricing is not a sign of a breakdown of contestability but rather a manifestation of its normal functioning. If the constraint on profit imposed by entry is potent, the only way for firms with large fixed and continuing sunk costs to survive will be to engage in price discrimination of the most sophisticated variety that is workable. Firms that are more efficient in finding and carrying out better pricing strategies will survive against less creative firms (Baumol, 2005).

2.3 Authority's view of efficient and ineffective price discrimination conflicts with the literature

It has long been known that discriminatory prices can enhance output and increase economic welfare. Researchers such as (Hausman & MacKie-Mason, 1988), (Varian, 1996), and (Baumol, 2005), have provided elegant and powerful results that confirm this observation. The tests set out by the Authority and its peer reviewers, for distinguishing efficient and inefficient price discrimination, are at odds with this established literature. A simple, every day, example may help illustrate the difference by comparing the Authority and its peer reviewers' characterisation of price discrimination with Varian's, (1996), touchstone—whether or not such pricing increases or decreases total output.

Most movie theatres offer discounted ticket prices for children. Community theatres would not appear to be earning monopoly profits, and indeed might be better characterised as a declining industry; [4] hence the ubiquity of price discrimination in this industry is unlikely to be evidence of the use of market power.[5]

Were the Authority regulating movie theatres, its proposed rule (option 7 discussed above) would deem price discounts for children inefficient as there is no material cost difference in making a seat in a theatre available to a child, relative to an adult.

It is not clear what Mr Hunt means by a 'price below the economic cost of supply'. From the appendix to his letter, it seems Mr Hunt considers the relevant measure of economic cost is the price or cost of the marginal unit (the last unit sold to meet demand).[6] For a theatre, this cost may be the full priced seat. A discounted price for children would therefore be deemed an inefficient price discount under Mr Hunt's rule.

Mr Duignan would be interested in whether any other movie goer, who would have been prepared to pay more than the child's discount price, but less than the full fare, had been 'crowded out' and missed out on seeing the movie. As Varian shows, that question falls short of the analysis required to assess whether the discount is inefficient price discrimination, as account needs to be taken of the additional output (in this example, the seats sold to the family).

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[4] See for example, https://www.forbes.com/sites/enriquedans/2020/12/05/imagine-a-world-without-movie-theaters.

[5] For the origin of the argument that discriminatory pricing need not require monopoly power, see (Levine, 2002).

[6] We show below that Mr Hunt's test misreads theory; a profit-maximising price discriminator would set prices in each sub-market at levels at which its marginal cost is equal to its marginal revenue.

A family that could not purchase discounted prices for children (because those tickets were sold to a movie goer willing to pay more than the discounted fare but not the full price) may choose not to view the movie and to undertake some other family activity. Mr Duignan's test would require the theatre owner to forgo the custom of an entire family to avoid crowding out a customer who might have been willing to pay more than the child's discounted price. The test from the literature (e.g., Varian) would allow an assessment of whether more tickets are sold when some prices are discounted, than are sold at a uniform price, which is the reason why profit-seeking theatres discount prices for some customers; put simply, theatres do not charge lower prices to older customers and to children out of charity but because economic welfare enhancing market conditions force them to do so.

This simple example helps illustrate three conceptual foundations from the literature on efficient and inefficient price discrimination:

- the relevant test is whether or not such pricing increases or decreases total output (Varian, 1996); society is better off, in the simple example, if the whole family can attend the movie rather than the individual who would have paid a little more than the child's ticket price.
- efficient price discrimination (that is welfare enhancing) requires customers to be segmented in a way they cannot resell to others willing to pay more (Baumol, 2005); that is, welfare-enhancing markets include measures such as 'use-it-or-lose-it' contracts, and do not prohibit them as proposed by the Authority under its Option 2 (Electricity Authority, 2021, pg 36 -37).
- efficient price discrimination involves complex considerations that cannot be determined centrally but are discovered in market processes.

2.4 Subsidy-free prices

As an input to its Discussion Paper, the Authority asked Mr Hunt to "estimate the size of any subsidy that NZAS receives under the new supply agreement" (Hunt, 2021, pg 6). Mr Hunt says prices are subsidy-free if they lie between the incremental and stand-alone costs of supplying the relevant service. In support of this statement Mr Hunt cites the Commerce Commission's Input Methodologies Reasons Paper, (2010, para 7.2.5).

The statement referred to by Mr Hunt is in a footnote to the cited paragraph. This footnote refers the reader to Chapter 3 of the Input Methodologies for further discussion. In Chapter 3 the Commerce Commission discusses the incremental cost and stand-alone cost by a single entity supplying two or more services in combination (see for instance, paragraph 3.2.8).

In economic regulation of a monopoly, a subsidy-free price for a specific service lies between the incremental cost to the entity of providing that service, and the efficient standalone cost of that supply. The standalone cost is usually estimated in regulatory setting from the efficient costs of a hypothetical new entrant.[7]

[7] For a fuller explanation of the application of incremental cost and standalone cost in price setting, (Mayo & Willig, 2018).

Mr Hunt explains that his analysis focussed on whether the price paid by NZAS is below the incremental cost of supply as that would indicate a subsidy is being provided (Hunt, 2021, pg 6). He adopts, as a measure of incremental cost of supply, the cost of meeting additional supply from thermal power stations in the North Island. If the price charged to NZAS is below the cost of thermal generation in the North Island, Mr Hunt concludes that the difference is a subsidy.

There is no economic validity to Mr Hunt's approach. At best, his comparator of the cost of thermal generation in the North Island might be some proxy of standalone cost—that is, the amount the smelter might have to pay for supply from a hypothetical efficient new entrant. It is not a measure of the incremental cost of supply from Meridian's and Contact's hydro stations.

Mr Hunt's test would imply that an efficient new entrant should not enter into a contract at a price below the cost of the highest cost existing supplier, which is approximated by thermal generation cost, as that lower price would be a subsidy. Mr Hunt's view of a price subsidy would make it very difficult for the Authority to pursue its objective of promoting competition for the long-term benefit of consumers.

There is therefore no economic foundation to the Authority's claims that generators have subsidised the price of electricity to the smelter (Electricity Authority, 2021, p. ii).

2.5 Efficient prices

The Authority claims that the Tiwai contracts (which result in other consumers paying more than they would had the smelter closed production) distort signals for investment in generation and electrification, thereby compromising the efficient transition to a low emissions economy (Electricity Authority, 2021, p. ii). The Authority makes these claims from an analysis of static efficiency; however, the implications it draws for dynamic efficiency from its static analysis are incorrect.

Standard welfare economics provides economists with tests for whether marginal prices are (Pareto or statically) efficient—that is, where no consumer could be made better off without making some other consumer worse off. Marginal pricing refers to the price of an additional unit of service. A *necessary* condition for Pareto efficiency is that the *marginal willingness to pay* must equal *marginal cost*.

Each of the italicized terms has a formal meaning in economics. The phrase, 'marginal willingness to pay', refers to the willingness of the customer to pay for an incremental unit of the service. 'Marginal cost" refers to the cost of providing an incremental unit of the service. A 'necessary' condition means that the condition must hold for the situation to be economically efficient, but the condition may hold in circumstances without implying that the situation is efficient.

The static efficiency requirement—that the price for the marginal unit equate marginal willingness to pay and marginal cost—does not mean that every unit of the good or service be sold at marginal cost. This is a key conclusion from the literature on efficient price discrimination discussed above. Consider, for example, the illustration provided by Varian (1996). In this example, a supplier offers a service that has fixed costs of $10 and marginal costs of $2 per unit supplied. Two customers each want to purchase one unit of the service. Customer A is willing to pay $12 for the service; customer B is willing to pay $5.

A number of pricing scenarios are possible, including:

a) The service could be sold at marginal cost—in this case the producer would sell the service at a price of $2 to each of the customers, but would fail to recover its fixed costs, which is not economically viable.
b) The service could be sold at a flat price—in this case the supplier would find it most profitable to set a price of $12 and sell only to customer A. Customer B would not purchase the service even though it would be willing to pay a price that covers marginal cost.
c) Different prices could be charged to A and B—the supplier could set a price of $12 for customer A and $2 for customer B. Each customer would be served, and the supplier would be able to cover its full costs.

The variation in prices under scenario (c) is consistent with the condition for static efficiency, as the price at the margin equals the marginal willingness of customer B to pay. As customer A pays a price less than its willingness to pay, resulting in a consumer surplus, the pricing structure also meets the requirements of efficient price discrimination.

Price discrimination of this nature is ubiquitous in industries that exhibit large fixed costs; airlines, for example, operate sophisticated yield management systems whereby two passengers flying at the same time and in the same cabin class may have paid very different prices for their tickets. According to (Geradin & Petit, 2006):

> A key insight of economics is that price discrimination is most likely to expand output where the seller has declining average total costs. Expanding output through price discrimination is an essential strategy for firms facing problems of fixed cost recovery. Price discrimination allows firms facing large fixed costs (in practice all firms that make substantial investments) to expand their output and thus spread fixed costs over a large number of units.

3. The Authority's testing for inefficient price discrimination

3.1 The Authority observed output increasing from differentiated pricing

The Authority uses the 'Tiwai contracts' to illustrate its view of inefficient price discrimination (Electricity Authority, 2021, Appendix B). These contracts are a curious example for the Authority to select in its Discussion Paper for two reasons.

First, an increase in aluminium prices since the contracts were finalised means the contracts resulted in an increase in economic welfare relative to a scenario in which the smelter hypothetically exited, under the Authority's own approach to estimating economic impacts.[8] The Authority, in effect, is proposing regulatory options in its Discussion Paper that would have precluded welfare enhancing contracts on the basis that it (the Authority) would not have foreseen that benefit when it applied its proposed tests and precluded the contract.

Second, the Tiwai contracts led to a large increase in electricity output relative to the Authority's counterfactual scenario of the smelter exiting New Zealand, as illustrated by the Authority in its figure 7, scenario (Electricity Authority, 2021, pg 55). The Authority's conclusion (supported by its peer reviewers) that this increase in output would have been anticipated to reduce welfare is clearly at odds with the expectation from the economics literature (e.g., Varian's touchstone discussed above).

One of two possibilities arise:

- the received economics literature is wrong, and the Authority has shown that price discrimination can expand output and be welfare reducing
- the Authority is mistaken.

In the following section, we show the Authority wrongly interprets its own analysis and Appendix B of its discussion paper provides an example of welfare enhancing price discrimination, not inefficient price discrimination as the Authority concludes.

3.2 Measuring an increase in total welfare

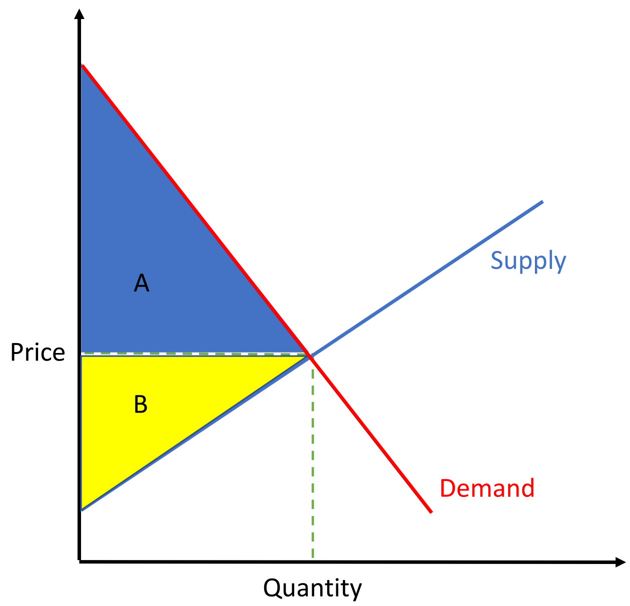
(Samuelson & Nordhaus, 1989) defined economics as the study of how societies use scarce resources to produce valuable commodities and distribute them among different people. Economists measure the total wellbeing of all participants in a market from the sum of consumer surplus and producer surplus.

[8] This means the willingness-to-pay by the smelter is likely to be higher now compared to what is assumed under the Authority's calculation of overall efficiency gain (loss).

Consumer surplus is the difference between the price a consumer is willing to pay for a good and the price they actually pay. In a textbook supply and demand diagram, consumer surplus is measured as the area above the market price and below the demand curve—the blue area A in Figure 1 below.

Producer surplus represents the difference between the price a seller receives for a good and the price they would be prepared to sell at. In a textbook supply and demand diagram, producer surplus is measured as the area above the supply curve and below the market price—the yellow area B in Figure 1 below.

Figure 1 Total welfare = producer plus consumer surplus



Hence, price discrimination that increases the sum of the producer and consumer surplus increases total welfare and therefore is efficiency-enhancing. An increase in the sum of producer and consumer surplus might result, for example, from a pricing strategy that shifts either (or both) the demand curve or the supply curve to the right in Figure 1.

3.3 Analysis undertaken by Authority

In its analysis set out in Appendix B of its Discussion Document, the Authority presents a series of stylized supply and demand diagrams.

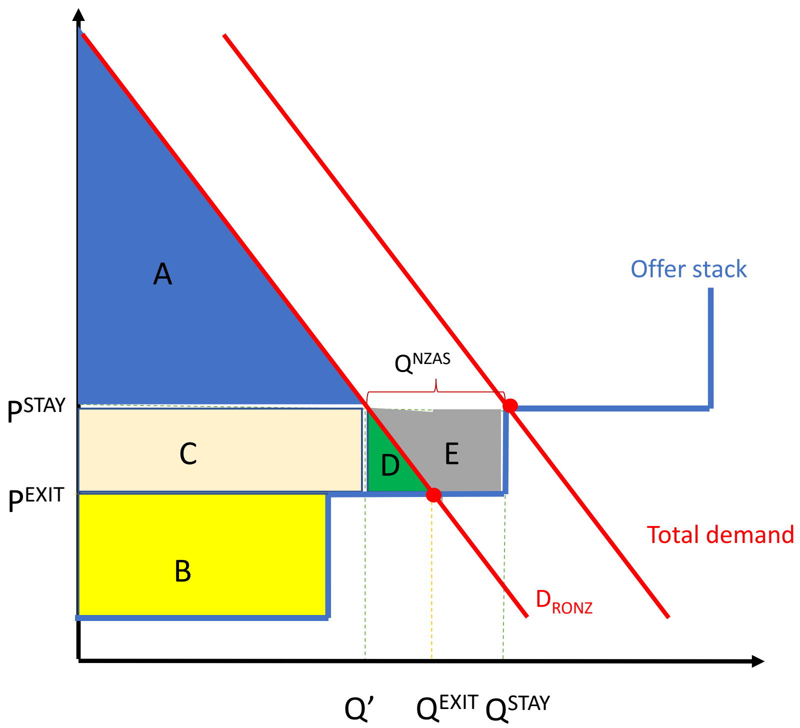
The Authority's analysis makes a number of simplifying assumptions. It assumes a normal year, and hence does not account for the benefit of load reduction provided by the smelter nor the prospect that additional high-cost generation might need to be run to maintain supply. Other attributes of the contracts and spot markets that are important to assessing the costs and benefits for New Zealand are not considered by the Authority (notably transmission charges paid by the smelter and locational pricing are excluded from the analysis).

The effect the Authority seeks to illustrate in its figures 7 to 13 is the impact on a market when commercial entities enter agreements at different prices. The Tiwai contracts give rise to this effect in the Authority's characterisation as:

- the quantity and price for electricity supplied to the smelter is determined under a contract-for-difference (CFD)[9]
- the quantity and price for electricity supplied to the 'rest of New Zealand' (R_{ONZ}) is determined by the intersection of the supply and demand curve after allowing for the supply to Tiwai.[10]

Figure 2 reproduces figure 7 from the Authority's Appendix B, with some areas coloured to assist in describing changes in consumer and producer surplus. As with the Authority's chart, the market price is shown as P^{EXIT} in the scenario the smelter exits, and at P^{STAY} in the scenario that the smelter remains. P^{STAY} is higher than P^{EXIT}, because a quantity of electricity, Q^{NZAS}, is supplied to the smelter (that is, supplied under the CFD) and hence higher cost generation is run to meet the demand by the rest of New Zealand, labelled R_{ONZ}. Because of the higher price, R_{ONZ} demands less electricity in the scenario where the smelter stays, consuming Q' rather than Q^{EXIT}.

Figure 2 Change in producer and consumer surplus



As with the Authority's diagrams, the supply curve is shown as steps, rather than a straight line, to represent the step changes in the operating cost of electricity generation plant as demand increases.

The Authority locates the exit price and the stay price on an unchanged offer curve, marked with red dots in Figure 2. This representation is incorrect as the Authority accepts some water would be

[9] The economic effect of a contract-for-difference is that the parties pay and receive the price negotiated in the contract for the quantity specified in contract.

[10] In reality, there would be many sub-markets (under the Authority's characterisation) as most wholesale electricity sales are governed by CFDs and other forms of contracts.

stranded—that is, the water could not have been used for generation—had the smelter exited. Hence, the offer curve under the exit scenario cannot be the same as the offer curve for stay. The likely implication (within the simplified structure of the Authority's analysis) is that the exit price would have been closer to the stay price, had the Authority correctly adjusted the offer curves under the exit and stay scenarios respectively.

The following areas of producer and consumer surplus are coloured in Figure 2:

- the blue triangle, labelled A, shows consumer surplus (this is the area above P^{STAY} and below the demand curve); this area A is unchanged whether the smelter stays or exits and therefore need not be considered further in an efficiency analysis
- the yellow rectangle, labelled B, shows producer surplus (this is the area below the P^{EXIT} and above the supply curve); this area is impacted by the lower willingness to pay by the smelter, as discussed below
- a loss in consumer surplus, because demand is 'crowded out' by the higher price, is represented by the green triangle and labelled D[11]
- an increase in producer surplus, coloured grey and labelled E; this area of producer surplus was excluded from the Authority's calculation as discussed below
- an increase in producer surplus matched by a decrease in consumer surplus, shown as the light yellow rectangle, labelled C, between P^{STAY} and P^{EXIT}; as the decrease in consumer surplus is matched by an increase in producer surplus, the total surplus illustrated by this area is unchanged and need not be considered further in an efficiency analysis.

3.4 Changes in producer and consumer surplus

We comment on four areas of the Authority's presentation of changes in producer and consumer surplus.

First, not shown on Figure 2, but accepted in the Authority's analysis, is additional producer surplus from using water for generation in the smelter stays scenario, when that water would have been stranded in the exit scenario. This additional value is measured by the volume of generation from stranded water multiplied by the difference between P^{STAY} and the marginal operating cost of hydro generation plant, P^{MC}.

Second, the Authority excludes from its analysis the producer surplus marked as E on Figure 2. This is not a correct treatment. Sufficient generation is dispatched to meet total demand, identified as Q^{STAY} in Figure 2. Generation that is dispatched is paid P^{STAY}. The area above the offer curve and below the market price is additional producer surplus—the producer surplus created from the increase in output.

[11] This triangle is often referred to as the 'deadweight loss', or Harberger triangle. The loss is a 'deadweight' because no-one benefits from the price distortion; Arnold Harberger first defined how to quantify the loss for price distortions due to taxation, see (Harberger, 1964).

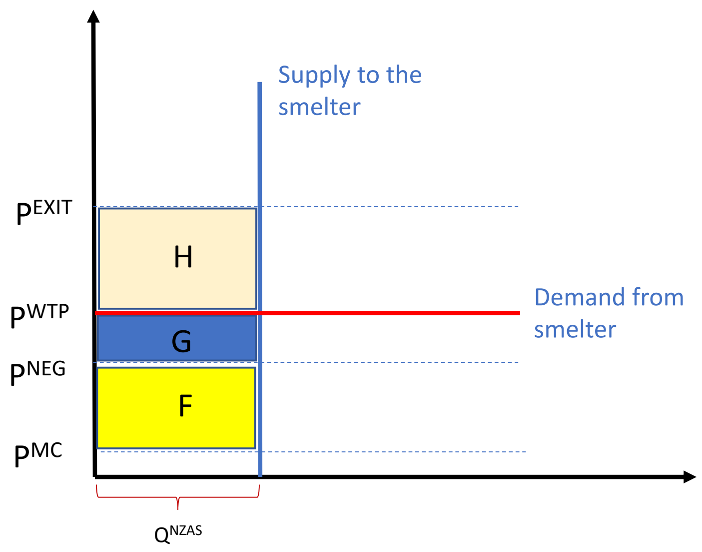
Third, the chart as drawn overstates the producer surplus, and understates the consumer surplus, from the supply to the smelter. To help illustrate these impacts, Figure 3 Change in producer and consumer surplus – smelter

shows prices and quantities in the supply of electricity to the smelter.

In Figure 3 Change in producer and consumer surplus – smelter

, P^{WTP} is the price the smelter is assumed to be willing to pay. P^{NEG} is the price negotiated between the smelter and the generators; that is, the CFD price. P^{MC} is operating costs to generators in meeting the electricity supplied to the smelter. As the price and quantity in this sub-market are set by the CFD, the demand curve is horizontal and the supply curve is vertical.

Figure 3 Change in producer and consumer surplus – smelter



The area of consumer and producer surplus from the supply to the smelter shown in Figure 3 Change in producer and consumer surplus – smelter

are:

the yellow rectangle, labelled F, in Figure 3 Change in producer and consumer surplus – smelter

- shows the producer surplus from the electricity supplied to the smelter; this an area above the cost to the generator of producing the output (P^{MC}) and below the sale price negotiated in the CFD, P^{NEG}. This area is already encapsulated in Figure 2 and need not be considered further
- the blue rectangle, labelled G, shows the consumer surplus from the electricity supplied to the smelter; this is the area above the price paid by the smelter, P^{NEG}, and below the smelter's willingness to pay, P^{WTP}; this surplus is not shown in Figure 2 because it is located in the area below the market price, and therefore needs to be accounted for explicitly in an assessment of efficiency changes

- the light yellow rectangle, labelled H, shows the opportunity cost, or lost producer surplus, incurred by generators in supplying the smelter; this areas equals the benefit the producers would have received by using the same water to supply R_{ONZ} in the exit scenario.

Finally, the Authority includes in its production cost estimates an allowance for transmission charges (hence, the producer surplus from electricity generated using stranded water is reduced by an allowance for additional payment of transmission costs). However, in the exit scenario, the Authority makes no allowance for the approximately $57 million per annum paid by the smelter for the cost of transmission, which if Transpower is to meet its revenue requirement, would be allocated to other transmission customers in the exit scenario.

3.5 Quantification of efficiency gains using the Authority's assumptions

Having identified the changes in producer and consumer surplus, we can quantify these changes using the same assumptions adopted by the Authority. These assumptions were set out by the Authority in its Discussion Paper and in the appendix to Mr Duignan's review. We list the assumptions in our Appendix B. Our calculations are shown in Table 1. In Appendix B we reproduce the sensitivity analysis presented by the Authority in its table 2.

Table 1 Change in total producer and consumer surplus $ million

Authority's table 2 assumptions	**Formulae**	**Lower bound Value**	**Upper bound**
Element			
Gain in producer surplus on additional volumes	$(Q^{STAY} - Q') \times (P^{STAY} - P^{EXIT}) - (P^{STAY} - P^{EXIT}) \times (Q^{EXIT} - Q')/2$	92.11	8.10
Producer surplus on stranded water	$(P^{STAY} - P^{MC}) \times Q_{stranded\ water}$	$ 100.56	$ 100.56
Smelter consumer surplus	$(P^{WTP} - P^{NEG}) \times Q_{NZAS}$	$ 50.11	$ 50.11
Total gain in surplus		$ 242.79	$ 158.77
Less			
Opportunity cost on sales to smelter	$(P^{EXIT} - P^{NEG}) \times Q_{NZAS}$	-175.38	-175.38
Net efficiency gain		$ 67.41	-$ 16.60
Consistent treatment of transmission costs		$ 57.00	$ 57.00
Net efficiency on consistent application of Authority's approach		**$ 124.41**	**$ 40.40**

Hence, rather than an efficiency loss of $54 million to $117 million as arrived at by the Authority (Electricity Authority, 2021, pg 27),[12] the better measure of the total efficiency gains from the Tiwai contracts (relative to the exit scenario) is around $40 million to $120 million per annum, applying the Authority's assumptions consistently. This result is consistent with the expected outcome from output enhancing price discrimination.

[12] As we note in footnote 8, the willingness-to-pay by the smelter is likely to be higher now compared to what is assumed under the Authority's calculation of overall efficiency gain (loss). This means that if P^{WTP} is now $70 rather than $45, as assumed in the Discussion Paper, the Authority's analysis would result in efficiency gains between $6 million and $68 million.

The Tiwai contracts do result in a significant net gain to producer surplus under the Authority's characterisation of the contracts and its assumptions. In of itself, this observation is nothing more than the 'invisible hand of the market' at work;[13] generators were incentivised to negotiate a contract that resulted in a net benefit to New Zealand.

[13] The invisible hand is an economic concept that describes the social benefits and public good brought about by individuals acting in their own self-interests. The concept was first introduced by Adam Smith in The Theory of Moral Sentiments, written in 1759.

4. Conclusion

The Authority wrongly characterises the Tiwai contracts as an example of inefficient price discrimination. Rather than an efficiency *loss* of $57 million to $117 million as arrived at by the Authority, the better measure of the total efficiency *gains* from the Tiwai contracts (relative to a scenario in which the smelter ceased production) is around $40 million to $120 million per annum, applying the Authority's assumptions consistently.

There appear to be two sources of error in the Authority's approach:

- The Authority did not arrive at a clear problem definition—its descriptions of the problem differ from its reviewers and the reviewers differ among themselves; without a clear problem definition, there was no solid foundation for its analysis
- The analysis undertaken by the Authority were not grounded in the extensive literature on the issue it was investigating—price discrimination. The tests from the literature are not mentioned at all, and the Authority seemed unaware that it was arriving at conclusions at odds with the relevant literature.

There is no economic foundation to the Authority's claims that generators have subsidised the price of electricity to the smelter. The Authority's claim was based on an analysis that compared the price paid under a commercially agreed contract by a low-cost supplier (hydro generation), with the cost of the highest cost existing supplier (approximated by thermal generation). The Authority's definition of a subsidy would imply that an efficient new entrant should not enter into a contract at prices below that charged by the incumbents; a test that would make it very difficult for the Authority to pursue its objective of promoting competition for the long-term benefit of consumers.

The Tiwai contracts do result in a significant net gain to producer surplus under the Authority's characterisation of the contracts and its assumptions. In of itself, this observation is nothing more than the 'invisible hand of the market' at work; generators were incentivised to negotiate a contract that resulted in a net benefit to New Zealand.

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Appendix A Simple model of price discrimination

Inefficient price discrimination

We present here a simple theoretical model of a scenario where price discrimination strategy may give rise to inefficiencies, measured as a loss of total surplus, compared to the adoption of uniform price. Using an example from (Viscusi, Vernon, & Harrington, 2001), let us assume there are two types of customers in the market (A and B), with their demand curves expressed respectively as:

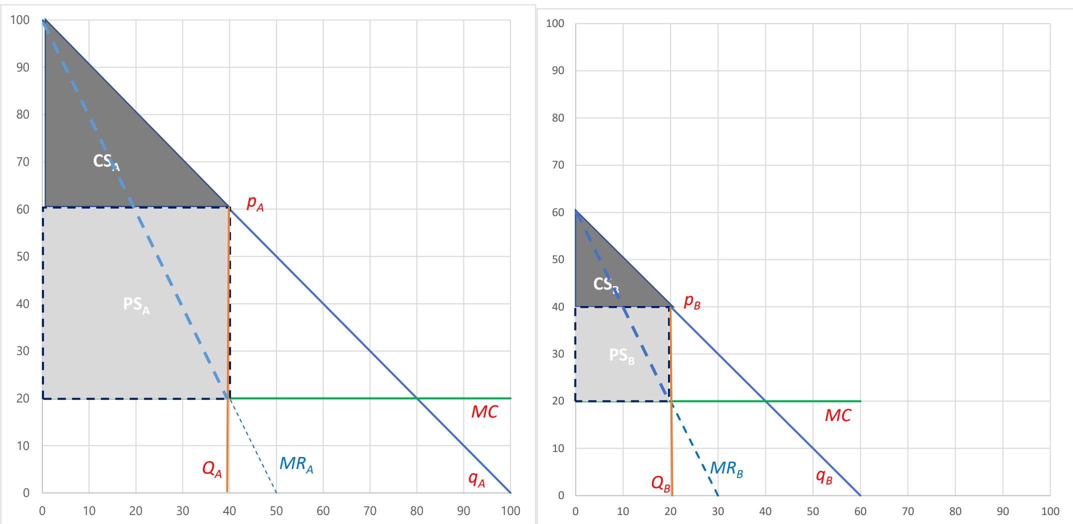
$$q_A = 100 - p_A$$

$$q_B = 60 - p_B$$

We further assume, for simplicity, that the marginal cost (MC) is constant at $20. Under normal profit-maximisation solution, the producer sets the marginal revenue for customer A (MR_A) equal to the marginal revenue from customer B (MR_B), and both equal to the marginal cost (*MC*). Given the above demand curves for customers A and B, the profit-maximisation solution requires to sell 40 units to customer A at a price of $60 per unit and 20 units to customer B at a price of $40 per unit.

The higher price is charged to the customer with lower elasticity of demand.[14] As (Viscusi, Vernon, & Harrington, 2001) note, if the elasticities were not different, the prices would be the same and discrimination would not be profitable.

The graphs below show the demand and marginal revenue curves[15] respectively for customers A (left-hand side) and B (right-hand side), with the corresponding total surplus, as a sum of consumer surplus (CS) and producer surplus (PS).[16]



[14] The elasticity of demand for customer A is 1.5, while the elasticity of demand for customer B is 2.

[15] MR_A = 100-2q_A and MR_B = 60-2q_B

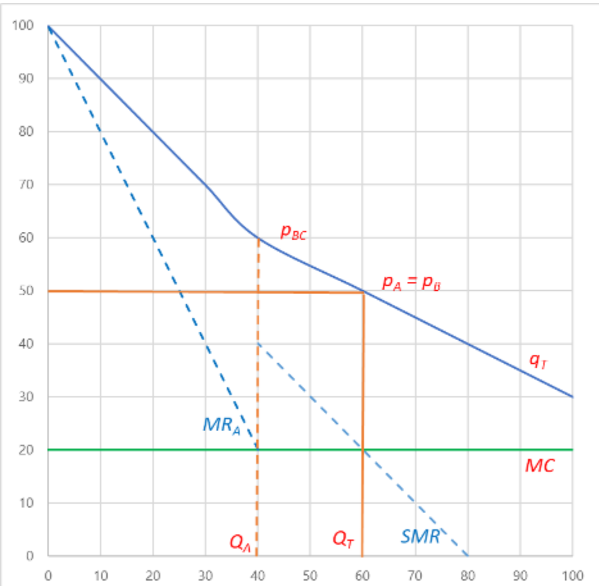
[16] Consumer surplus is represented by the triangle CS and producer surplus is represented by the square PS.

Table below shows the breakdown of consumer surplus (CS), producer surplus (PS) and total surplus (TS) per each customer, under the price discrimination strategy adopted by the producer:

	Customer A	**Customer B**
Price	P_A = $60	P_B = $40
Quantity consumed by each customer	Q_A = 40	Q_B = 20
TOTAL quantity consumed	Q_T = 60	
Consumer surplus	CS_A = $800	CS_B = $200
Producer surplus	PS_A = $1,600	PS_B = $400
Total surplus	TS = $3,000	

Total surplus (TS) under the price discrimination strategy is therefore $3,000.

Let us now assume that the supplier is not allowed to price-discriminate between the two customers. In this case, the supplier offers the same product to both customers at uniform price of $50 per unit sold. The uniform price is obtained at intersection of the simple marginal revenue (SMR)[17] curve associated with the total demand curve (q_T) and the marginal cost MC, as illustrated in the graph below.



Given the uniform price is set below the choke price of $60 for customer B ($p_{BC}$), the customer B is willing to buy 10 units. At the same time, the customer A is willing to buy 50 units at the uniform price of $50.

[17] See footnote 53 in (Viscusi, Vernon, & Harrington, 2001) and pages 196-197 in (Robinson, 1969).

The graphs below show the demand curves respectively for customers A (left-hand side) and B (right-hand side), with the corresponding total surplus, as a sum of consumer surplus (CS) and producer surplus (PS), under this uniform price scenario.

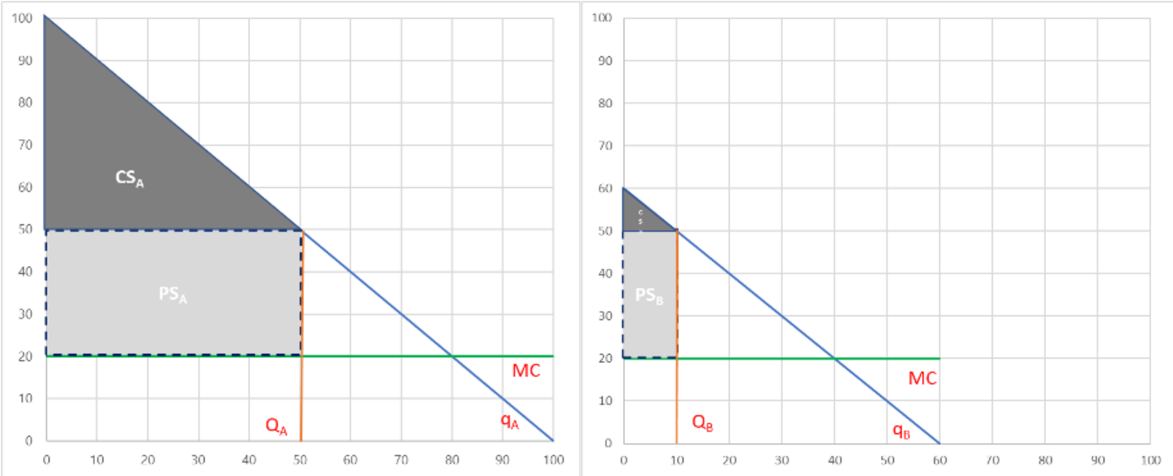


Table below shows the breakdown consumer surplus, producer surplus and total surplus per each customer, under the uniform price scenario:

	Customer A	**Customer B**
Price	P_A = \$50	P_B = \$50
Quantity consumed by each customer	Q_A = 50	Q_B = 10
TOTAL quantity consumed	Q_T = 60	
Consumer surplus	CS_A = \$1,250	CS_B = \$50
Producer surplus	PS_A = \$1,500	PS_B = \$300
Total surplus	TS = \$3,100	

The analysis above shows that total surplus under the price discrimination scenario is lower than the total surplus under the uniform price scenario. This means that the price discrimination strategy, in this case, would give rise to inefficiencies (i.e., reduction of \$100 in total surplus).

Efficient price discrimination

We now assume that the demand from customer B is smaller than before, with the choke price for customer B (p_{BC}) at \$40, and it is represented by the following demand curve:

$$q_B = 40 - p_B$$

Under normal profit-maximisation solution, the producer sets again the marginal revenue for customer A (MR_A) equal to the marginal revenue from customer B (MR_B), and both equal to the marginal cost (*MC*). Given the change in demand curve for customer B, the profit-maximisation solution requires to sell 40 units to customer A at a price of $60 per unit and 10 units to customer B at a price of $30 per unit. The higher price is again charged to the customer with lower elasticity of demand.[18]

The graphs below show the demand and marginal revenue curves[19] respectively for customers A (left-hand side) and B (right-hand side), with the corresponding total surplus, as a sum of consumer surplus (CS) and producer surplus (PS).

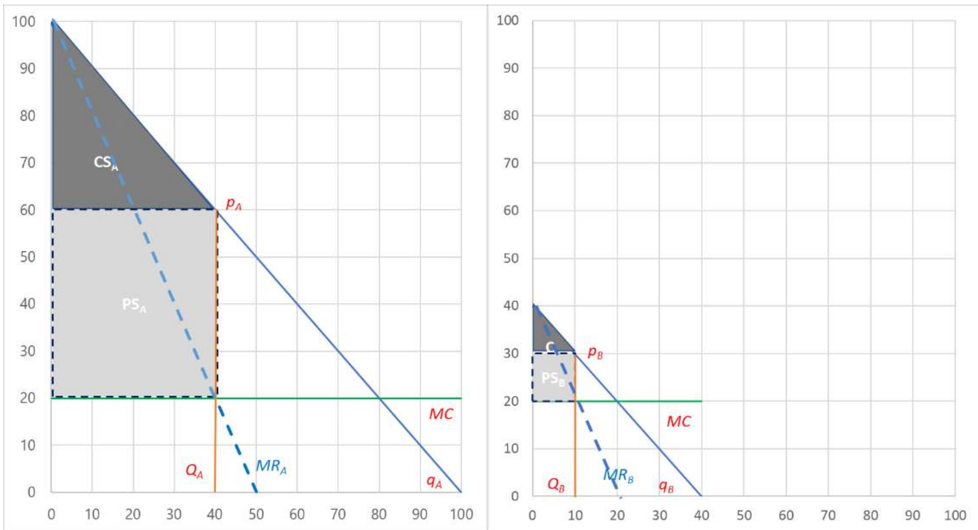


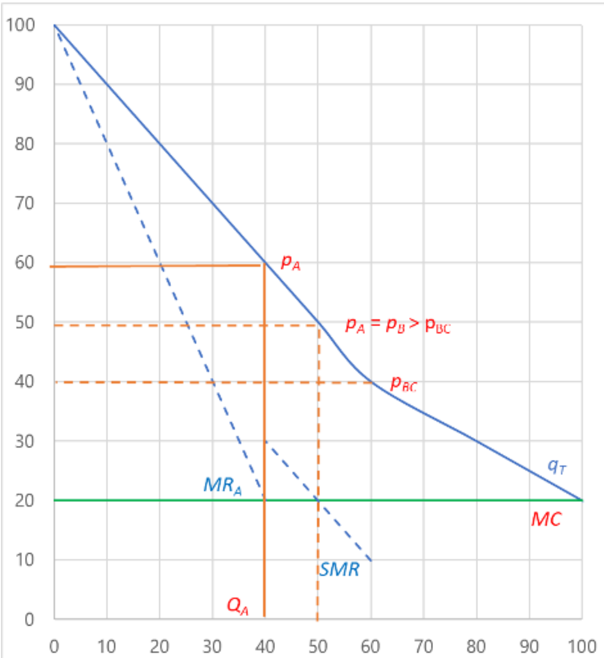
Table below shows the breakdown of consumer surplus, producer surplus and total surplus per each customer, under the price discrimination scenario:

	Customer A	Customer B
Price	P_A = $60	P_B = $30
Quantity consumed by each customer	$Q_A = 40$	$Q_B = 10$
TOTAL quantity consumed	$Q_T = 60$	
Consumer surplus	$CS_A = 800$	$CS_B = 50$
Producer surplus	$PS_A = 1{,}600$	$PS_B = 100$
Total surplus	TS = 2,550	

[18] The elasticity of demand for customer A is 1.5, while the elasticity of demand for customer B is now 3.

[19] $MR_A = 100\text{-}2q_A$ and $MR_B = 40\text{-}2q_B$

Let us now assume that the supplier is not allowed to price-discriminate between the two customers. In this case, the supplier is prepared to offer the same product to both customers at uniform price of $50 per unit sold. This uniform price is obtained at intersection of the simple marginal revenue (SMR)[20] curve associated with the total demand curve (q_T) and the marginal cost MC, as illustrated in the graph below.



However, as shown on the graph above, this uniform price sits above the choke price for customer B. This means that the customer B will exit the market under the uniform price, so the equilibrium price in the market is now determined solely by the demand curve from customer A. Given the demand curve from customer A, and therefore the marginal revenue MR_A, the profit-maximisation solution requires to sell 40 units to customer A at a price of $60 per unit.

Table below shows the breakdown consumer surplus, producer surplus and total surplus under the uniform price scenario:

	Customer A	**Customer B**
Price	P_A = $60	P_B = $60
Quantity consumed by each customer	$Q_A = 40$	$Q_B = 0$
TOTAL quantity consumed	$Q_T = 40$	
Consumer surplus	CS_A = $800	$CS_B = 0$

[20] Given the demand curves for customers A and B, the marginal revenue associated with total demand is now $MR = 7 - Q_T$

Producer surplus	PS_A = $1,600	PS_B = 0
Total surplus	TS = $2,400	

The above scenario shows that by adopting price discrimination strategy, the producer is able to expand the output, and increase the total welfare by $150 (from $2,400 under uniform price to $2,550 under price discrimination).

Price discrimination, in this case, gives rise to efficiencies, compared to the uniform price.

Appendix B Quantification of producer and consumer surplus

Assumptions adopted from the Discussion Document and Mr Duignan's review:

Table 2 Assumptions and area calculations

Parameter	Assumed value
P^{STAY}	$90 / MWh
P^{EXIT}	$70 / MWh
P^{WTP}	$45 /MWh
P^{NEG}	$35 /MWh
P^{MC}	$ 8 /MWh
Q^{NZAS}	5.011 TWh = 572 MW x 8,760 / 1,000,000
Q^{EXIT}	37.264 TWh = 36.454 TWh x (1+(-0.1) x ($70-$90)/$90)
Q'	36.454 TWh
Area C (Figure 2)	(P^{STAY}-P^{EXIT}) x Q' = ($90-$70) x 36.454 TWh = $729.08 million
Area D (Figure 2)	(Q^{EXIT}-Q') x (P^{STAY}-P^{EXIT})/2 = (37.264 TWh - 36.454 TWh) x ($90-$70)/2 = $8.10 million

Table 3 Reproducing Authority sensitivity analysis from its Table 2

	Net efficiency gain (lower bound)	Net efficiency gain (upper bound)
Baseline	**124.41**	**40.40**
Exit price = $60/MWh	214.50	100.63
Stay price = $80/MWh	67.86	22.31
RoNZ Elasticity ε= -0.05	128.46	36.35
Average stranded water = 120 MW	110.04	26.03
WTP = $55/MWh	174.52	90.50

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